REPORT 1093-30

REPORT
by
THE OHIO STATE UNIVERSITY RESEARCH FOUNDATION
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SEMI-ANNUAL REPORT
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I. INTRODUCTION

This report summarizes the results obtained on research programs under NASA Grant NsG-74-60, during the period starting 1 October 1965 and ending 31 March 1966. In addition the last section of this report outlines some programs planned for the future.

II. RESEARCH RESULTS

For the sake of continuity we shall briefly review the work reported in the previous report dated 1 October 1965. We summarized some of the results of solar radiation measurements obtained at the Kitt Peak National Observatory, which were later presented completely in a technical report number 1093-27. It was mentioned that the equipment used at Kitt Peak was to be adapted for use with the two 50-foot White-type absorptions cells so that absorption measurements of water vapor and other gases could be made. Finally, some preliminary results and a plan of work were presented for the submillimeter-wavelength laser project and the 10.6 micron CO_2 laser project.

A. Measurement of the Absorption Bands of Water

Four tests have been conducted to investigate water-vapor absorption in the submillimeter region. Test 1 yielded a water-vapor absorption spectrum from 50 to 1000 microns wavelength at a pressure of 4.4 mm Hg and a path length of 200 ft. Test 3 yielded the same kind of spectra but at a pressure of 1.1 mm Hg with the same path length of 200 ft. The other two tests were vacuum runs used to calibrate the absorption spectra obtained above. From these experiments, graphs for the attenuation coefficient attenuation were obtained. These have been written up in detail and were presented in report 1093-29.

The absorption positions in the two tests agree with the published theoretical values. This is an indication of the reliability of the whole system, but further extensive investigation of the absorption spectra, the attenuation coefficient, and the dB loss measurements are being postponed until the improvements mentioned below are accomplished.

The detector and the electronics show a significant time delay and this has a definite degrading influence on the measurement of the absorption spectra. A stepping motor and a control unit have been built to drive the movable drive mirror in the Michelson interferometer in steps instead of continuously. With the new system the mirror is moved in steps of ten microns each and 5 seconds are allowed between each step for the electronic system's output to approach a steady state before the data are taken.

The response of the system to a unit step function is also to be investigated so as to justify a theoretically derived equation which relates the actual incident radiation intensity function to that obtained experimentally with continuous mirror movement. When this relationship is known, one can refine the previously taken data and also reduce experimental time extensively in the future runs.

B. Digital Data Recording System

During the development of the interferometric receiver and its use at Kitt Peak, the instrument output was recorded on punched paper tape using an analog-to-digital system which was developed from a number of components available at that time in the laboratory. The analog-to-digital converter of this system consisted of an electro-mechanical servo system driving a digital shaft encoder. The shaft encoder output was stored in a thyratron-driven relay matrix (DATEK unit) which was then interrogated sequentially to provide the three decimal output digits which were punched into the paper tape. This unit had several disadvantages: only three decimal digit accuracy could be obtained; the performance of the electro-mechanical servo system with respect to linearity, response to small changes of input voltage, and damping left quite a bit to be desired; and because of the use of an electro-mechanical servo system and the thyratron-driven relays, the desired operating reliability could not be achieved.

For the above reasons, the analog-to-digital conversion and recording system was extensively modified during the past few months. The electromechanical servo and the DATEK unit were replaced by an integrating digital voltmeter, and a solid-state logic and control unit was built to control the operation of the voltmeter and to permit its output to be recorded sequentially on punched paper tape. This new system permits the analog output from the instrument to be digitized with a minimum of four-place decimal accuracy, and in the tests run to date has shown itself to be extremely reliable. The use of the new digital system in place of the old one will yield a minimum of one order of magnitude reduction in the

digitizing noise and will give increased reliability in the operation of the instrument.

C. Submillimeter Wavelength Laser Studies

The construction of the 1.5-meter external-mirror CO_2 laser was completed. This laser was built primarily to study some of the characteristics of molecular lasers and in particular the CO_2 - N_2 type molecular laser with the hope of extrapolating the results to other molecular systems so as to find additional laser lines in the far-infrared region of the spectrum. A letter describing the novel construction of this CO_2 laser and the components used for its operation has been submitted and accepted for publication by the American Journal of Physics.

The 5-meter laser has been used as an oscillator to measure the gain through a 1.5 meter amplifier. The gain at the different rotational transitions of the CO_2 laser has been studied at different CO_2 - N_2 or CO_2 - N_2 - He pressures to gain an insight into the inversion mechanisms.

A systematic study of the vibrational spectra and energy levels of simple molecules was started so as to discover energy resonance conditions required for transfer of energy from metastable vibrational level of N_2 to other molecules in order to establish population inversion. Already several candidates have presented themselves as being promising.

A new laser is being constructed. This laser is made of glass parts bolted together. The advantage of such a laser is manifested in the ease of its assembly and disassembly for use with experimental gases which polymerize in discharges and require frequent cleaning of the glass discharge tube. This laser minimizes the services required of a glass blower. This laser is also designed to be used in studies of thermally pumped lasers. However, at present, we are limited in our studies of inversion mechanism and the detection of new laser lines due to a lack of a fast response detector. We are planning to obtain such a detector.

We are at present cooperating with the Physics Department of The Ohio State University to measure the wavelength of several of the CO_2 and CO laser lines very accurately so as to re-determine some of the CO_2 and CO vibrational and rotational constants. This knowledge is useful in predicting the absorption spectra at very high temperatures.

III. RESEARCH PLANS FOR THE COMING PERIOD

A. Absorption Measurements of Submillimeter Waves in the Atmosphere

After the completion of the improvements now being made, the water-vapor absorption lines will be studied extensively using 3 different path lengths and several different pressures. The line-broadening effects of N_2 will also be investigated. The same absorption measurements will be performed on the atmospheric constituents NO_2, N_2O and CO. Investigation of O_2, HCN, SO_2, and some other gases are also considered.

B. Submillimeter Laser Study

As far as the generation and the study of coherent submillimeter sources are concerned, we shall continue our parameteric study of the CO_2 laser, such as making gain measurements under various conditions. The goal of this study is mainly to understand the energy transfer mechanisms taking place in the CO_2 laser. We are planning to study some new gas systems for possible long-wavelength laser sources as soon as our experimental laser setup has been completed. Meanwhile, theoretical work on the infrared spectra of various simple molecules will continue.